

North Anna Power Station Earthquake Assessment

DOE-NE

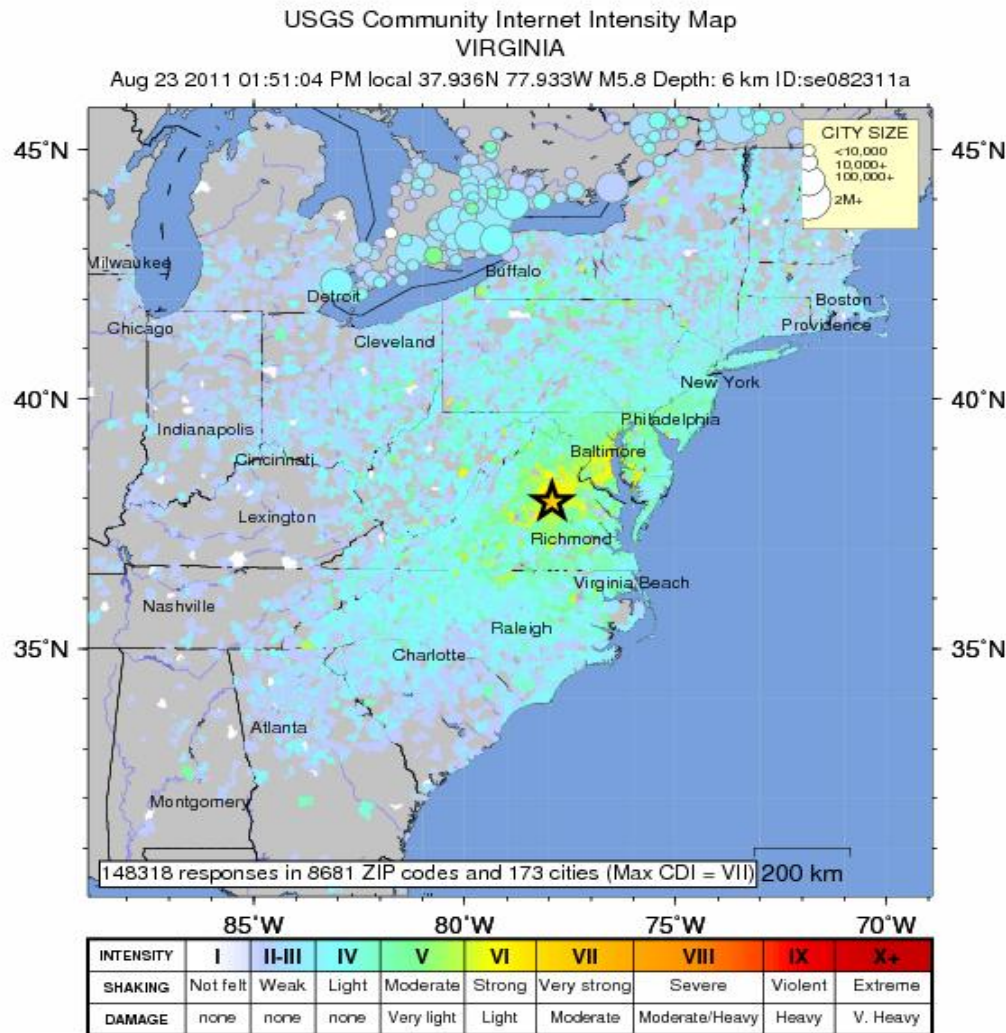
2012 Nuclear Reactor Technologies Summit

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Nuclear Development**

August 23 Central Virginia Earthquake felt over a wide area of the East Coast



- Magnitude 5.8 event; largest in over 100 years

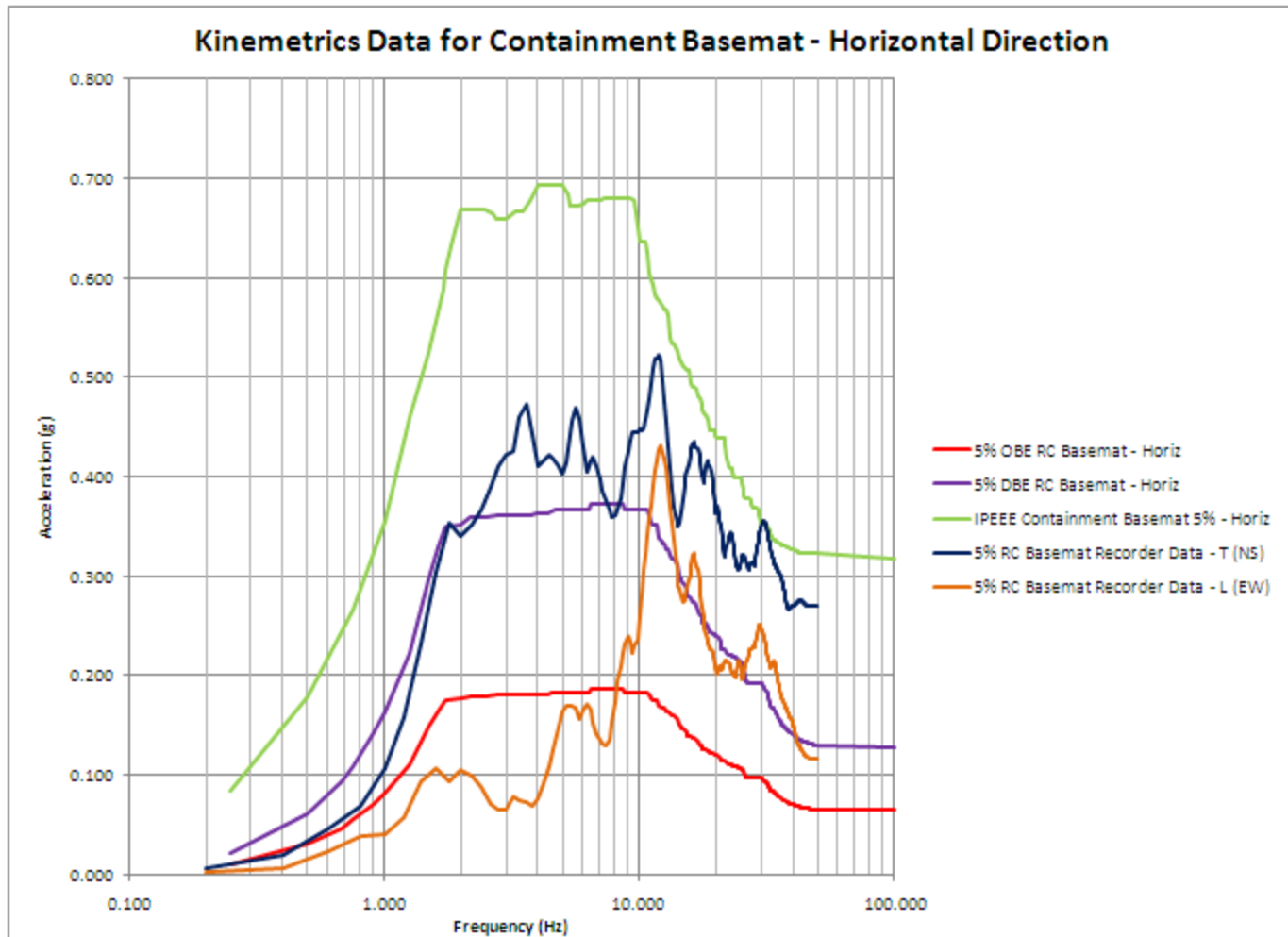
- Epicenter approximately 11 miles SW of North Anna

- Both Units 1 and 2 automatically shut down

- Offsite power lost; emergency diesels started and loaded in 8 seconds

- Offsite power restored later same evening

Response Spectra Comparisons



Forecasting Seismic Damage

Key factors

- Acceleration (vertical, north/south, east/west)
- Frequency of the vibration
- Duration of strong motion

Seismic acceleration response spectra

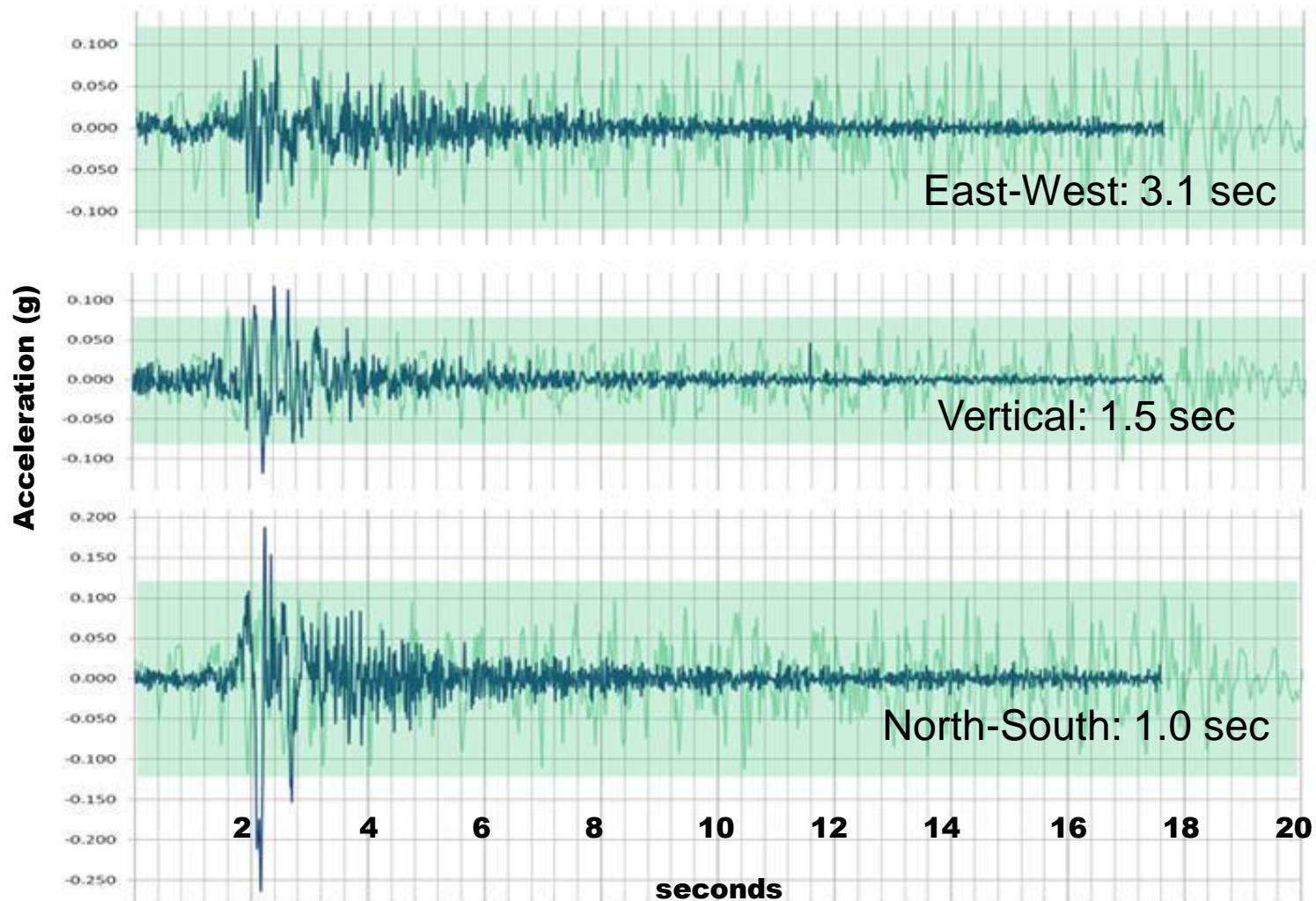
- Used to conservatively design plants
- Does not account for duration

Cumulative Absolute Velocity (CAV)

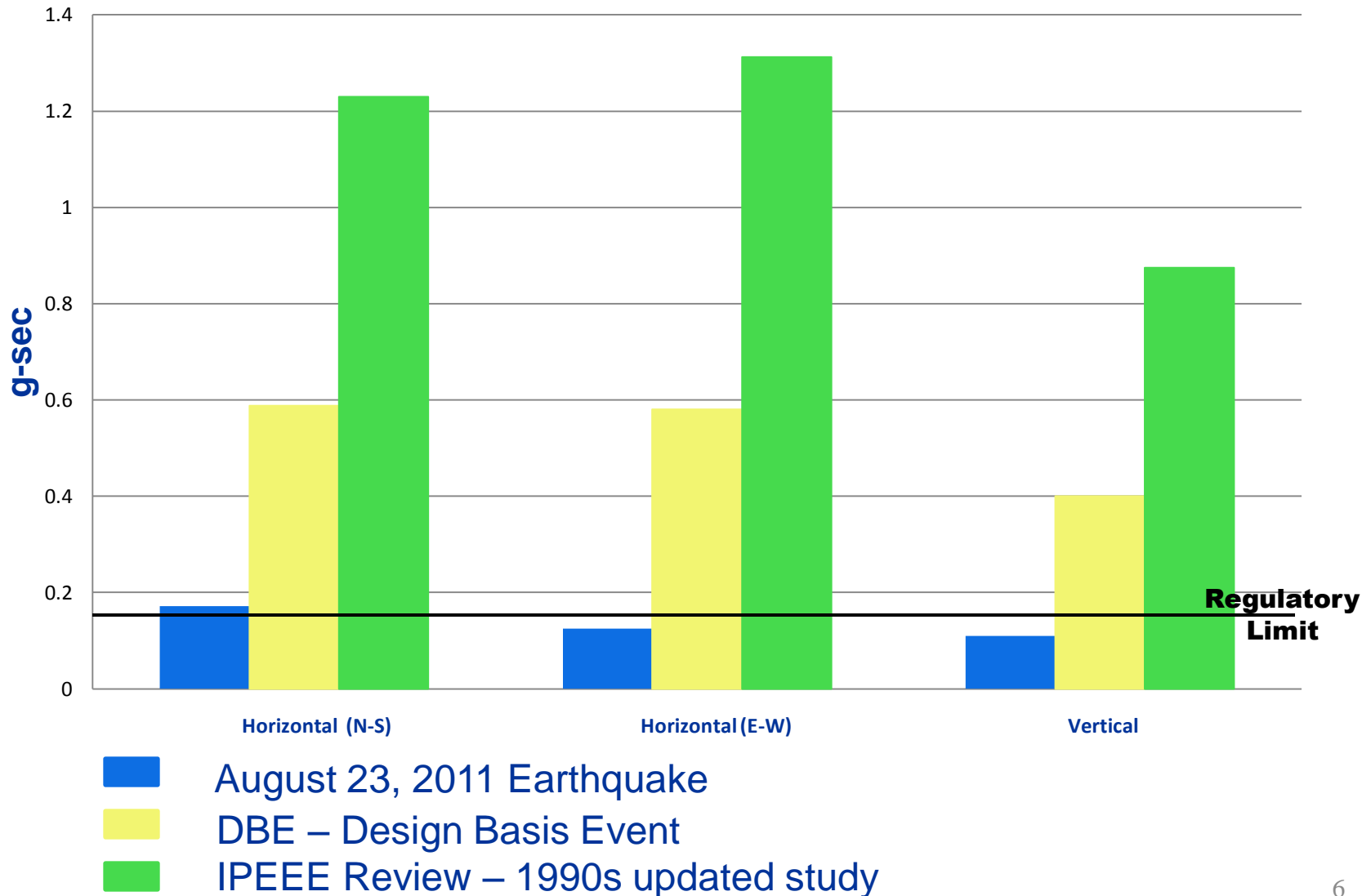
- Integrates all three factors
- Best indicator of energy imparted
- Best indicator of damage

August 23rd Earthquake:

A strong, but very short event



CAV Comparisons: Regulatory Guide Slightly Exceeded in One Dimension



North Anna Has Significant Design Margin

- Conservatism in analytical methods
- Conservatism in American Society of Mechanical Engineers Code
- Accident load design of greater capacity
- Conservatism in seismic test standards

Previous Evaluations Established Significant Margins Beyond Design Basis

The Plant Told the Story

Unit 2 Turbine Building



Non-Safety Related
Demineralizer
Tanks

Base Pedestal



Unit 1 Containment



Surface Crack In Interior Containment Wall

Dry Cask Storage



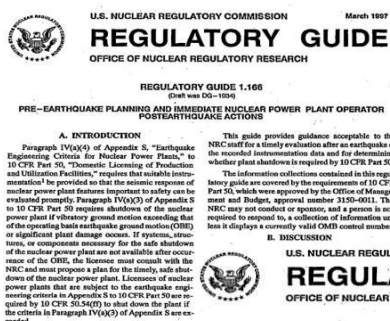
Casks moved
between 1 and
4½ inches



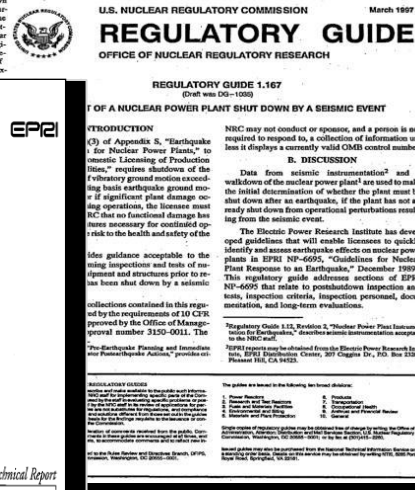
**Dominion Complied with
and Went Beyond
Regulatory Guidance**

Regulatory Guidance

Station restart readiness assessment actions based on NRC-endorsed guidance



RG 1.166, *Pre-earthquake Planning and Immediate Nuclear Power Plant Operator Post-earthquake Actions*, March 1997



RG 1.167, *Restart of a Nuclear Power Plant Shut Down by a Seismic Event*, March 1997

Guidelines for Nuclear Plant Response to an Earthquake



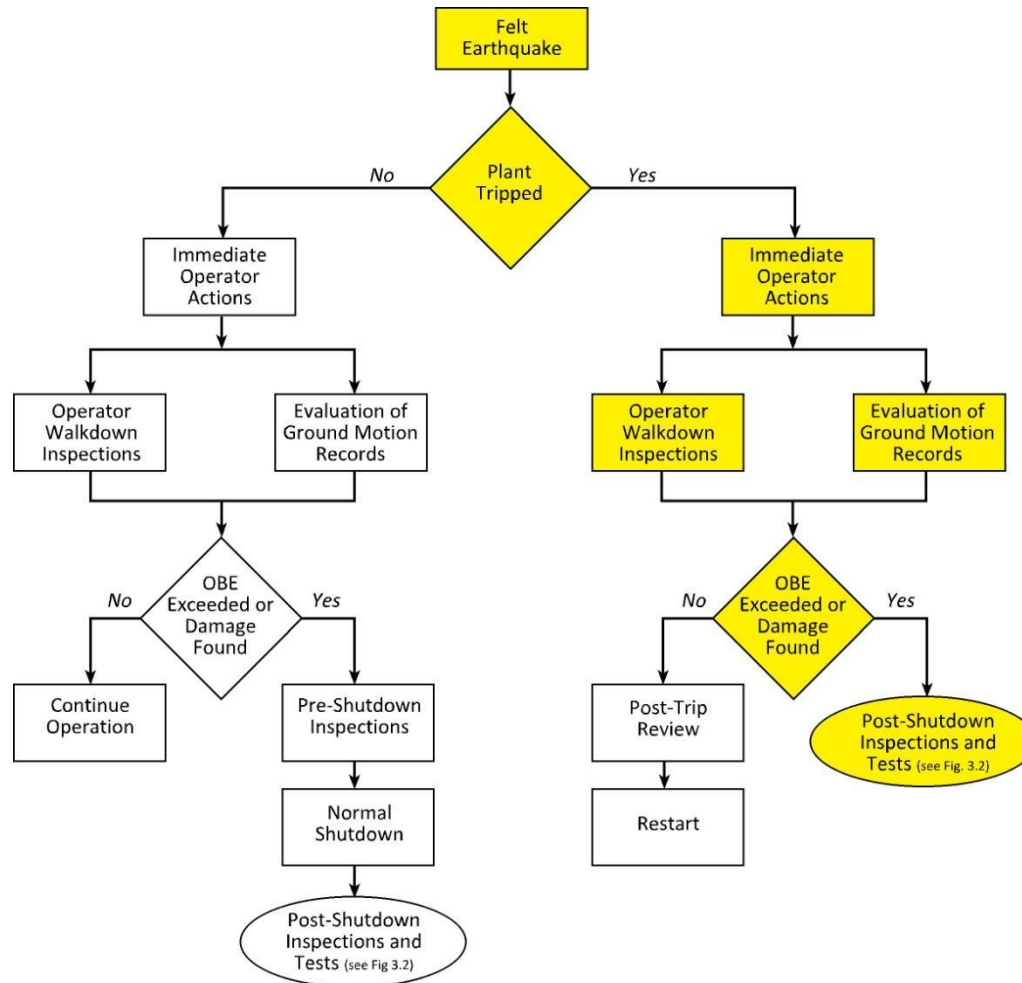
Technical Report

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EPRI NP-6695,
Guidelines for Nuclear Plant Response to an Earthquake,
December 1989

EPRI NP-6695 Figure 3-1

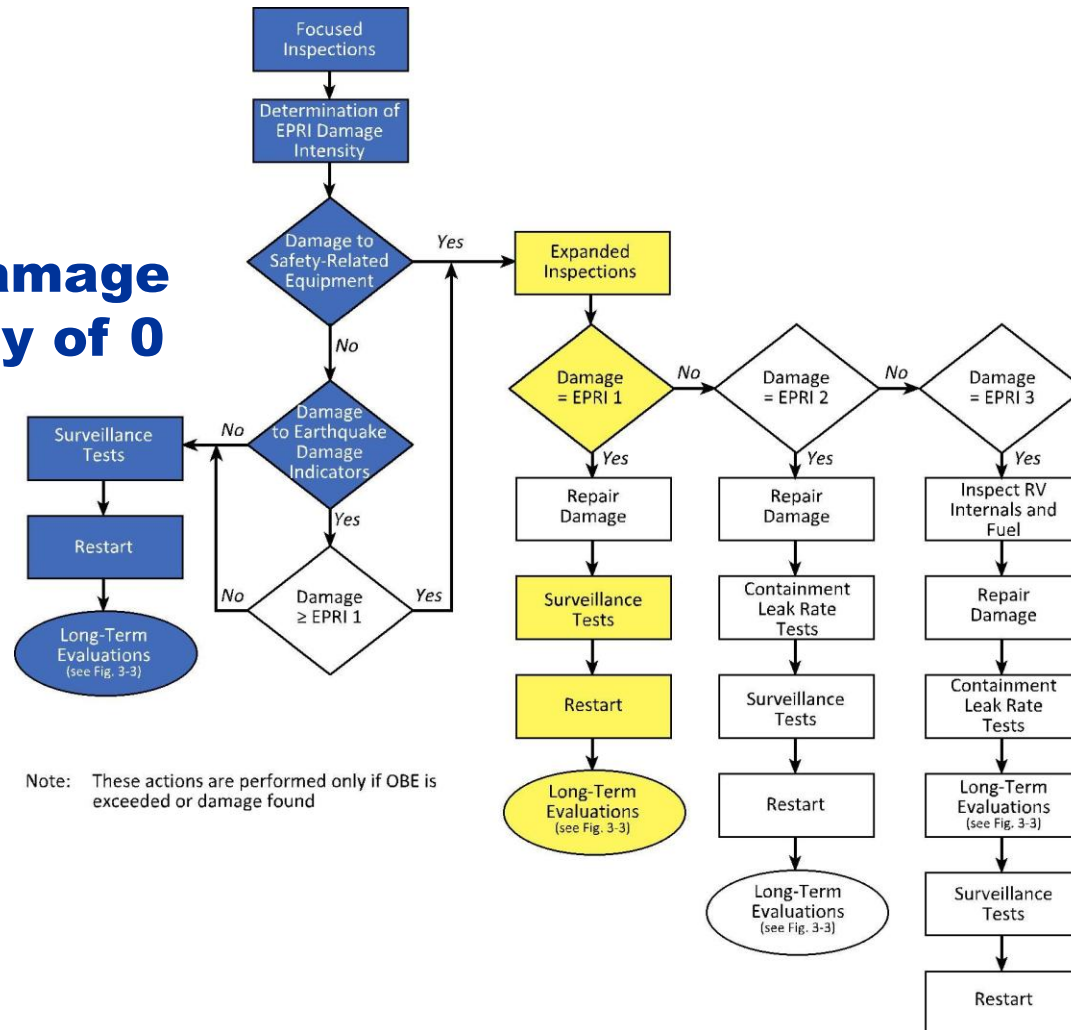
Short-Term Actions



EPRI NP-6695 Figure 3.2

Flow Diagram of Post-Shutdown Inspections and Tests

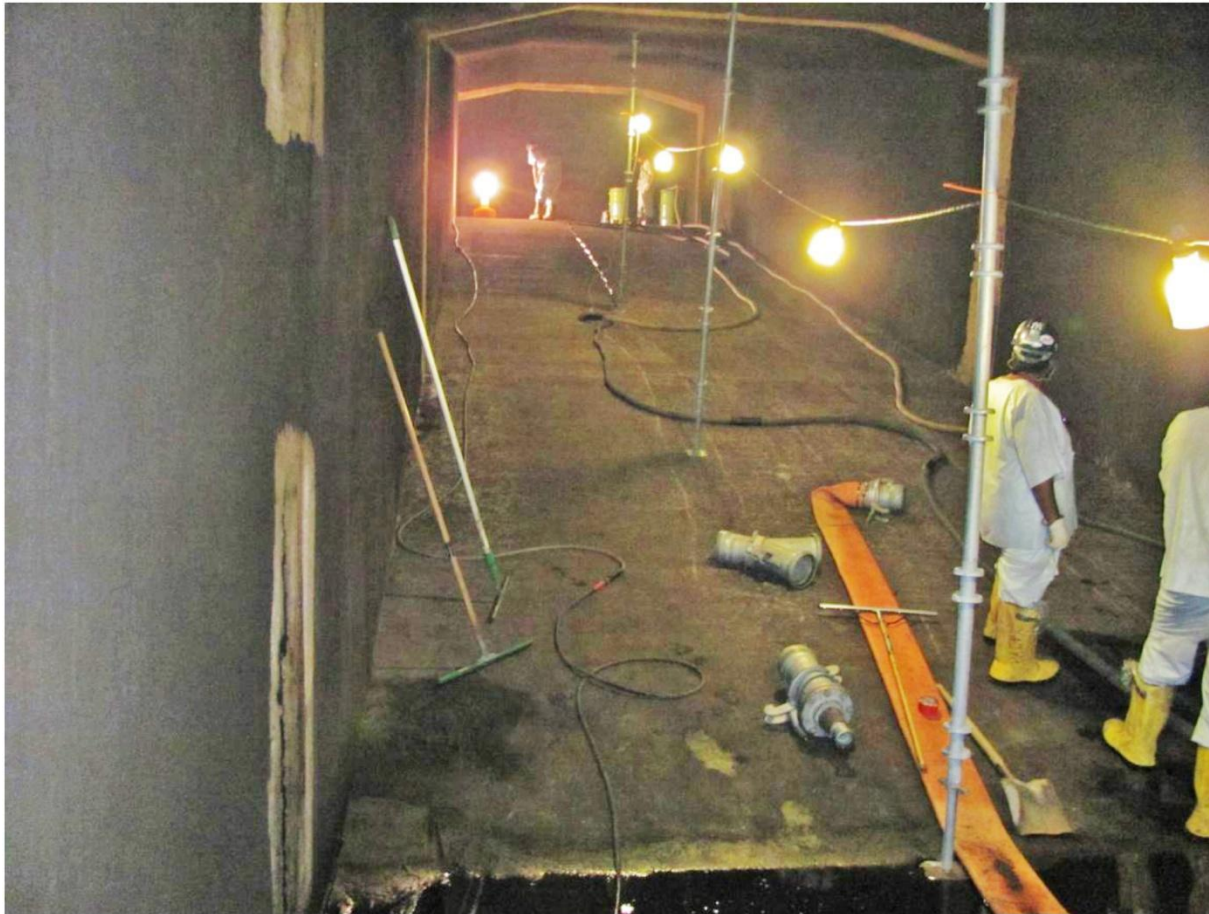
EPRI Damage Intensity of 0



Demonstration Plan

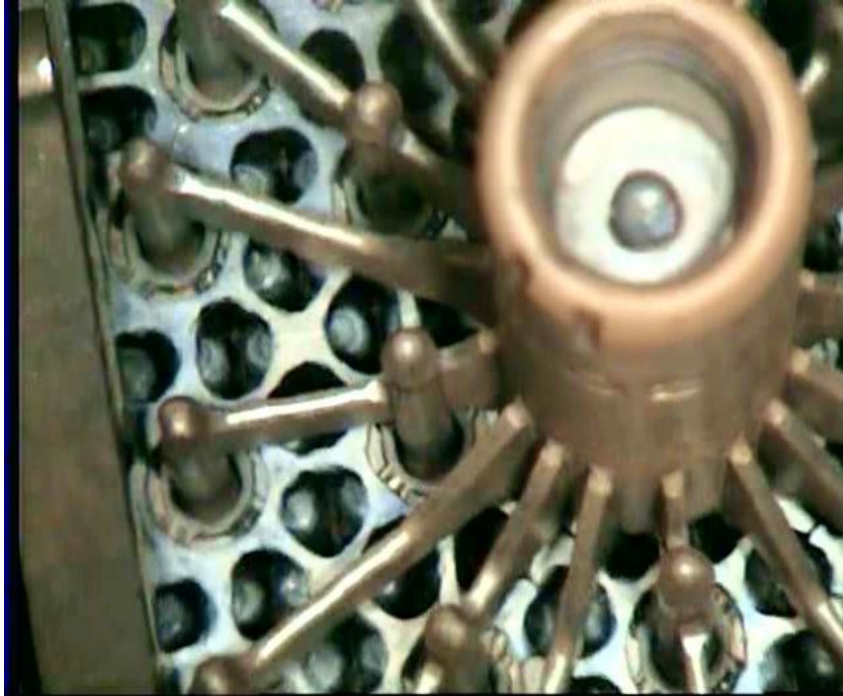
- Conservatively Inspected Beyond EPRI Damage Intensity “0” Classification
- Assessments & Evaluations for NRC
 - Requests for Additional Information (~ 130)
 - Onsite Inspections
 - Augmented Inspection Team
 - Restart Readiness Inspection Team
- Root Cause Evaluation of Reactor Trip

Investigated Components Most Likely to be Damaged



Unit 2 Tunnel Inspection

Extensive Fuel Inspections



Visual inspection of RCCA hubs



Examination of underside of
a mid-span mixing grid

Buried Piping



~ 100 ft of safety-related buried pipe visually inspected
with wall thickness verified by Ultrasonic Testing

Chemical Addition Tank

HCLPF value
= 0.19
No seismic
damage
identified



Boric Acid Storage Tank



HCLPF value
= 0.21
No seismic
damage
identified

Inspection Results

- ✓ 134 System inspections completed
- ✓ 141 Structure inspections completed
- ✓ 46 Low HCLPF inspections completed
- ✓ ~ 445 Surveillance Tests/unit through Mode 5
- ✓ ~ 29 tests/unit after exceeding Mode 4

Inspections Confirmed EPRI Damage Intensity of “0”

North Anna Inspection Summary

Process

- More than 100,000 hours
- \$21 million in inspection, testing, & evaluation
- Exceeded NRC endorsed guidance

Findings

- No functional damage to safety systems

Result

- NRC authorized restart 11/11/2011

Subsequent Actions

Short-Term Actions



- ✓ Installed Key Seismic Monitoring Equipment
- ✓ Revised Procedure to Respond to Earthquake



Long-Term Actions

- Install permanent free-field seismic monitoring instrumentation
- Re-evaluate safe shutdown equipment (components with identified lower margins)
- Perform seismic analysis of recorded event consistent with EPRI guidance
- Maintain seismic margins in future modifications
- Revise the North Anna Safety Analysis Report

Summary

- Acceleration criteria were briefly exceeded in certain directions and frequencies by a strong, but very short duration earthquake
- Previous evaluations establish safe shutdown systems, structures and components can handle peak accelerations above design basis
- No safety-related systems, structures or components required repair due to the earthquake
- No significant damage was found (or should have been expected) and results of expanded tests and inspections have confirmed expectations

Some thoughts going forward

- First application of NP-6695 at an operating plant
- Very good guidance, lessons learned communicated to EPRI
- NRC staff was not familiar with the document, or the RG's
- NRC required much more inspection and analysis for restart
- Staff indicated at ACRS January 20 that they are revising RG to impose additional requirements
- CAV threshold for OBE
- Much debate about the need to change design basis
- New CEUS model for source characterization will be a major resource impact on the industry
- Updating attenuation model will also be important